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Introduction

Two alternatives for breeders to match cattle resources with other production resources and market requirements are (1) identify a breed that is a good fit for the production requirements or (2) use systematic crossing of breeds that will complement each other most effectively to provide for the most profitable combination of characteristics. In either alternative, selection within breeds can be used to change the genetic values of specific traits to increase adaptability to the production system. The study reported here evaluates the genetic relationships among growth and carcass traits and assesses responses expected from selection.

Procedure

Data from 2,453 steers were analyzed. The steers were part of the germ plasm evaluation (GPE) program at MARC. Samples of steers from each breed-of-sire group were slaughtered at a commercial packing plant. One side of each carcass was transported to Kansas State University for detailed evaluation. The side was separated into wholesale cuts and processed into closely trimmed, boneless retail cuts, except that a small amount of bone was left in short loins and in rib cuts. No more than .3 inch of fat was left on the surface of retail cuts. Lean trim for ground beef from all wholesale cuts was trimmed to contain 25 percent fat. Retail product in this study was the sum of roast and steak meat and lean trim. Fat trim was the sum of fat trim from cuts and the kidney and pelvic fat (kidney included).

Results

Overall means, heritabilities, and genetic and phenotypic correlations are presented in Table 1. *Heritability* is the fraction of the observed differences between animals caused by average genetic differences. *Genetic correlations* measure the average genetic association between traits. *Phenotypic correlations* measure the total association (genetic + environmental) between traits.

Estimates of heritability from this study were in reasonable agreement with the average from other studies except for gain from birth to weaning, which was distinctly lower (.07 *vs* .30) and feedlot gain, which was higher (.57 *vs* .34). It is possible that the Hereford and Angus cows used in this study may have restricted the genetic potential of growth of their calves to weaning, which was compensated for under the *ad libitum* postweaning feeding conditions.

Predicted response to selection for feedlot gain, side weight, retail product percentage, or decreased fat thickness. Correlated responses to selection for feedlot gain (criterion 1 in Table 2) were essentially the same as response to selection for side weight (criterion 2 in Table 2) because the heritability of feedlot gain was higher than side weight (.57 *vs* .43), and the genetic correlation between them was high (.89). Selection for increased growth rate through greater daily gain in the feedlot or side weight resulted in sizable increases in weight of retail product, fat trim, and bone. Although retail product represented the largest fraction of the increase in side weight, the net change in composition produced a decline in retail product and bone percentages on an age constant basis. When compared at a constant side weight, retail product and bone percentages increased and fat trim percentage decreased. Maturity differences associated with composition are maximized in contrasts at a constant carcass weight. These results suggest that selection for increased growth rate would lead to leaner, later maturing types.

Selection for retail product percentage (criterion 3 in Table 2) would cause relatively little change in side weight, increase weight and percentage of retail product and bone, and decrease weight and percentage of fat trim and marbling.

Although it is not possible with current technology to assess retail product weight or percentage directly, the measurement of fat thickness in the live animal by probe or ultrasound techniques provides a viable alternative for changing carcass composition by selection. There may be some practical limitations in obtaining accurate measures of fat thickness on bulls and heifers because the variation in fat thickness among animals in breeding condition is much less than among steers fattened for market. Selection for reduced fat thickness (criterion 4 in Table 2) would not alter side weight appreciably, but would increase the percentages of retail product and bone and decrease fat trim. On a weight constant basis, selection for reduced fatness would lead to greater changes in retail product percentage than selection for feedlot gain or side weight, but about 40 percent less change than expected if selection could be based directly on retail product percentage.

Response in fat thickness followed the pattern of response in fat trim percentage, and response in rib eye area followed the pattern of response in retail product percentage because of their high genetic correlations with these traits.

Selection criteria that increased retail product percentage also decreased marbling score. The expected decrease in marbling score was small when selection was for feedlot gain or side weight.

Genetic increases in growth rate favor growth of lean tissue relative to fat. Environmental increases in growth rate, such as increased energy intake, favor growth of fat tissue relative to lean. Expected responses to selection for rate of gain are increased market weight and retail product, but less fat (at a constant weight) and an increase in mature size in the cow herd. Expected responses to selection for decreased external fat thickness are increased weight and percentage of retail product, but no change in market weight or mature size of cows. Equal selection emphasis for rate of gain and fat thickness reduces the expected increase in market weight and mature size, and the net increase in market weight would be due to retail product weight.

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[2]For a detailed description of the analysis reported here, see Journal of Animal Science 55:1319-1329, 1982.

Table 1.—Age constant means($\overline{x}$), heritabilities (h^2), and genetic and phenotypic correlations[a]

Item	$\overline{x}$	h^2	1	2	3	4	5	6	7	8	9	10	11
1. Feedlot gain, lb/day	2.37	.57		.72	.66	–.15	.37	.15	.61	–.12	.17	.32	.07
2. Side weight, lb	311.5	.43	.89		.84	–.31	.62	.34	.72	–.34	.36	.43	.13
3. Retail weight, lb	212.7	.58	.73	.81		.23	.13	–.19	.77	–.07	–.05	.60	–.07
4. Retail percentage	68.8	.63	–.13	–.11	.46		–.91	–.98	.06	.50	–.74	.27	–.37
5. Fat trim weight, lb	58.6	.47	.40	.45	–.12	–.91		.94	.13	–.64	.77	–.03	.36
6. Fat trim percentage	18.6	.57	.12	.13	–.44	–.98	.94		.14	–.65	.77	–.20	.38
7. Bone weight, lb	39.0	.57	.79	.71	.72	.14	.03	–.25		.40	–.08	.30	–.05
8. Bone percentage	12.6	.53	.02	–.20	.03	.35	–.51	–.51	.54		–.59	–.16	–.24
9. Fat thickness, in	.48	.41	.05	.08	–.34	–.74	.74	.78	–.30	–.52		–.15	.24
10. Rib eye area, in²	11.3	.56	.34	.44	.72	.53	–.28	–.48	.35	–.04	–.44		.03
11. Marbling[b]	10.5	.40	.15	.25	–.02	–.37	.42	.34	.15	–.04	.16	–.14	

[a]Genetic correlations are given at the left of the diagonal and phenotypic correlations at the right. Column numbers correspond to row numbers.
[b]Marbling scores: slight = 7, 8, 9; small = 10, 11, 12; modest = 13, 14, 15; moderate = 16, 17, 18, *etc.*

Table 2.—Expected response to one standard deviation of selection for (1) daily gain in feedlot, (2) side weight, (3) retail product percentage, and (4) reduced fat thickness

		Selection criteria (and standard deviations)			
Item	Basis[a]	1 (.258)	2 (26.5)	3 (3.3 pct)	4 (.134)
Side wt, lb	CA	11.7	11.4	–1.5	–.9
Retail wt, lb	CA	7.7	7.4	5.1	3.0
	CW	2.3	2.1	5.8	3.4
Retail percentage	CA	–.3	–.2	2.1	1.2
	CW	.7	.7	1.9	1.2
Fat trim wt, lb	CA	2.9	2.8	–7.0	–4.6
	CW	–2.8	–2.7	–6.2	–4.1
Fat trim percentage	CA	.3	.2	–2.2	–1.4
	CW	–.9	–.9	–2.0	–1.3
Bone wt, lb	CA	1.6	1.2	.3	.5
	CW	.9	.5	.4	.6
Bone percentage	CA	.0	–.1	.2	.2
	CW	.3	.2	.1	.2
Fat thickness, in	CA	.00	.00	–.05	–.05
	CW	–.03	–.03	–.05	–.05
Rib eye area, in²	CA	.2	.2	.4	.2
	CW	.1	.1	.4	.2
Marbling[b]	CA	.2	.3	–.5	–2.
	CW	–.2	–.1	–.5	–.2

[a]CA is at a constant age and CW is at a constant weight.
[b]Marbling: a change of one degree of marbling, e.g., from slight to small is equivalent to 3.0 score units.